NJDOT Bureau of Research
QUARTERLY PROGRESS REPORT

Project Title:	Evaluation of Poisson's Ratio
RFP NUMBER:	NJDOT RESEARCH PROJECT MANAGER: Mr. Anthony Chmiel
TASK ORDER NUMBER/Study Number: Task Order No. 128 / 4-26531	PRINCIPAL INVESTIGATOR: Thomas Bennert
Project Starting Date: 1/01/2004 **Original** Project Ending Date: 12/31/2005 **Modified Completion Date:**	Period Covered: 3rd Quarter 2005

Task	% of Total	% of Task this quarter	% of Task to date	% of Total Complete
Literature Search/Sensitivity Analysis	10%	50%	100%	10%
1. Material Collection	5%	0%	100%	5%
2. Laboratory Testing	70%	35%	90%	63%
3. Calibration	15%	30%	85%	12.75%
4. Reporting	10%	25%	25%	2.5%
Final Report				
TOTAL	100%			93.25%

Project Objectives:

- Conduct a sensitivity analysis to evaluate how the changing of the Poisson's Ratio affects the stresses and strains determined using elastic layer analysis procedures
- Evaluate the measurement of the Poisson's Ratio for aggregate base materials during the resilient modulus test and compare to available prediction equations
- Evaluate the measurement of the Poisson's Ratio for HMA materials during the dynamic modulus test and compare to available prediction equations

Project Abstract:

For the upcoming AASHTO Mechanistic Design Guide, the two main parameters needed for predicting the pavement stresses and strains are the modulus and the Poisson's Ratio. At the moment, the Poisson's Ratio is estimated based on the modulus of the material (both aggregate and HMA) or by the HMA temperature. However, this was developed using a minimal amount of material that does not represent the commonly used materials of New Jersey. Therefore, a research effort was developed to evaluate the current prediction methods and, if applicable, modify them to provide values that more closely represent materials from New Jersey.

1. Progress this quarter by task:

Testing of the unbound materials continued under the resilient modulus testing protocol developed in NCHRP 1-28A "Harmonized Test Methods for Laboratory Determination of Resilient Modulus for Flexible Pavement Design – Volume 1". During the resilient modulus test, horizontal LVDT's are used conducted in conjunction with the vertical LVDT's to provide a means of measuring the Poisson's Ratio from the dynamic loading. The first set of test results for an aggregate subbase material showed good comparisons with those found in NCHRP 1-28 (Figure 1). However, the measured values were for the granular subbase aggregate were lower than those typically assumed (0.3 to 0.4 for assumed values compared to 0.1 to 0.3 for measured). Two more soil types were tested using the same test method; 1) Sand with some gravel (subgrade soil) and 2) clay with sand and silt (subgrade soil). Again, the measured values were lower than those typically assumed. In fact, the clay soil only produced Poisson Ratio values between 0.05 and 0.25. This is significantly lower than typically assumed values for clayey-type soils (0.4 to 0.45). It is assumed that the reasoning for the difference in test results is that the test procedure used for the resilient modulus test does not keep the soil aggregate in the linear elastic range, where the

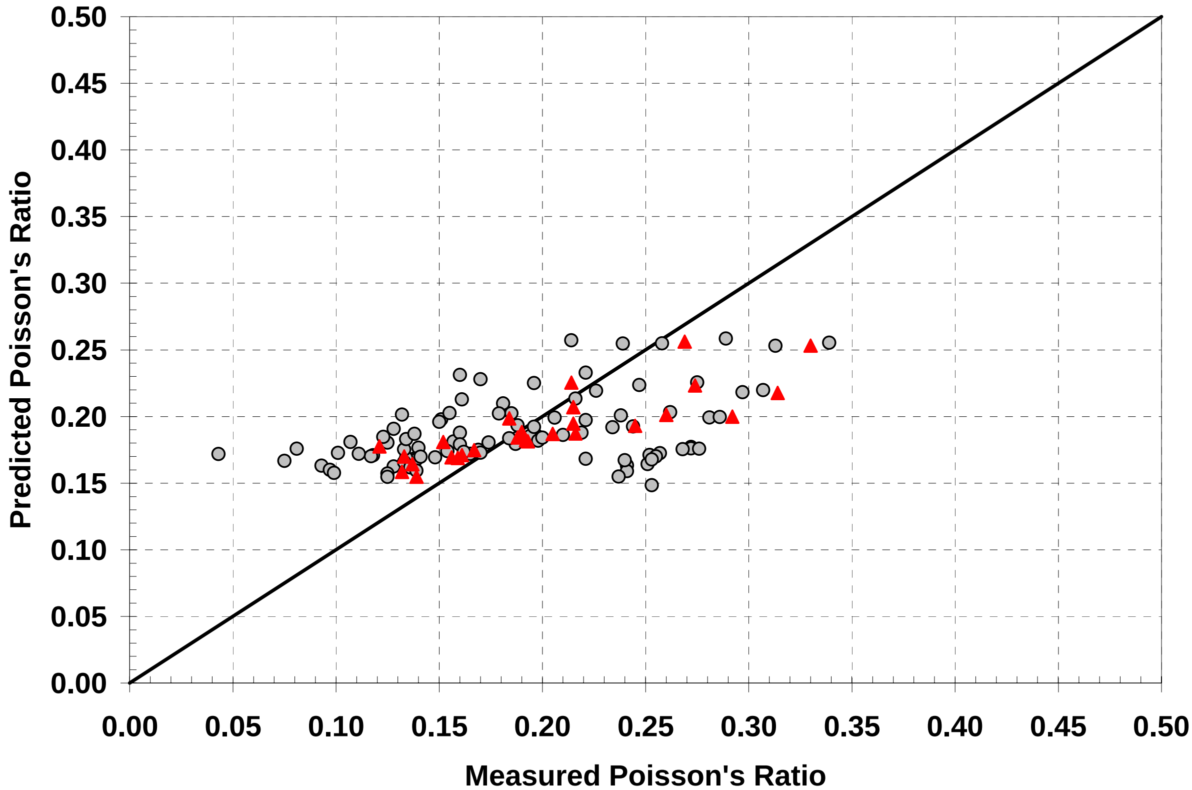

Figure 1 – NCHRP Database Measured vs Predicted and Laboratory Tested Measured vs Predicted Poisson's Ratio

concept of the Poisson's Ratio is valid. Instead, the test procedure actually allows up to 5% axial strain, therefore violating the law of linear elasticity.

Since it appeared that the laboratory testing of the Poissons Ratio for the unbound material using the resilient modulus test would not provide further meaningful results, two different sensitivity analyses were conducted. The first consisted of using evaluating how assuming different Poissons Ratio for unbound materials could influence the back-calculated modulus values from Falling Weight Deflectometer testing. The following conditions were used:

AC Layer Thickness = 7.65 inches
Crushed Limestone Base layer = 14.47 inches
Silty Sand Subgrade = 186.66 inches
Shale layer underlying subgrade
Applied Load = 9512 lbs
Radius of Load = 5.9 inches

The test section (SHRP Section F) used provided deflection basin data from the FWD testing. An elastic layer program, EVERCALC, was used to determine the back-calculated layer stiffness'. 120 simulations were conducted using EVERCALC with all of the pavement parameters held constant, except for the individual layer's Poisson's ratio values. Tables 1 to 6 show the determined layer stiffness' (all values are shown in ksi). What is interesting in the analysis is that as the Poisson's ratio of both the base and subgrade increases, the stiffness of the AC layer decreases. This is expected since an increase in Poisson's ratio is an indication of greater volume change and downward movement of the AC layer. However, what is somewhat unexpected for the analysis is that as the Poisson's ratio for the base and subgrade increases, the stiffness of the base layer also increases, with minimal change occurring in the subgrade.

Table 1 – Back-calculation of AC Stiffness (AC Poisson's ratio = 0.15)

		μ of Crushed Limestone Base				
		0.1	**0.2**	**0.3**	**0.4**	**0.5**
μ of Silty Sand Subgrade	**0.15**	993	992.8	992.5	991.9	990.3
	0.25	966	965.1	964.1	962.3	959.3
	0.35	927.6	926.3	924.4	921.9	917.8
	0.45	867.5	865.9	864	861.4	857.8

Table 2 – Back-calculation of AC Stiffness (AC Poisson's ratio = 0.45)

		μ of Crushed Limestone Base				
		0.1	**0.2**	**0.3**	**0.4**	**0.5**
μ of Silty Sand Subgrade	**0.15**	810.6	810.6	810.5	809.8	808.7
	0.25	788.7	788.1	787.2	785.9	783.5
	0.35	757.5	756.4	755	752.9	749.7
	0.45	708.5	707.2	705.7	703.9	700.9

Table 3 – Back-calculation of Base Layer Stiffness (AC Poisson's ratio = 0.15)

		μ of Crushed Limestone Base				
		0.1	**0.2**	**0.3**	**0.4**	**0.5**
μ of Silty Sand Subgrade	**0.15**	81.8	88.7	95.4	101.6	107.1
	0.25	88	95.5	102.7	109.6	115.7
	0.35	97.8	106.1	114.2	121.8	128.6
	0.45	116.5	126.1	135.1	143.5	150.8

Table 4 – Back-calculation of Base Layer Stiffness (AC Poisson's ratio = 0.45)

		μ of Crushed Limestone Base				
		0.1	**0.2**	**0.3**	**0.4**	**0.5**
μ of Silty Sand Subgrade	**0.15**	78	84.6	91	97.1	102.5
	0.25	83.4	90.6	97.5	104.1	110.1
	0.35	92	99.9	107.5	114.8	121.5
	0.45	108	116.9	125.5	133.5	140.7

Table 5 – Back-calculation of Subgrade Layer Stiffness (AC Poisson's ratio = 0.15)

		μ of Crushed Limestone Base				
		0.1	0.2	0.3	0.4	0.5
μ of Silty Sand Subgrade	0.15	31.8	31.7	31.4	31.2	30.8
	0.25	32.2	32.1	31.9	31.7	31.4
	0.35	31.4	31.4	31.2	31.1	30.9
	0.45	28.7	28.6	28.6	28.5	28.4

Table 6 – Back-calculation of Subgrade Layer Stiffness (AC Poisson's ratio = 0.45)

		μ of Crushed Limestone Base				
		0.1	0.2	0.3	0.4	0.5
μ of Silty Sand Subgrade	0.15	31.5	31.4	31.2	30.9	30.5
	0.25	32	31.8	31.7	31.4	31.1
	0.35	31.3	31.2	31	30.9	30.7
	0.45	28.6	28.6	28.5	28.4	28.3

Typical Poisson's ratio values used for FWD back-calculation are shown below, with their corresponding back-calculated modulus values;

AC Layer = 0.35, Back-calculated Modulus = 773.8 ksi
Aggregate Base Layer = 0.4, Back-calculated Modulus = 137.7 ksi
Subgrade Layer = 0.45, Back-calculated Modulus = 28.5 ksi

Based on the sensitivity analysis, the following conclusions can be drawn:

1) In the AC layer, differences as high as 12 % in the modulus can be made when comparing the possible Poisson's ratio conditions to the "Typically Assumed";
2) In the base layer, differences as high as 21% in the modulus can be made when comparing the possible Poisson's ratio conditions to the "Typically Assumed";
3) In the subgrade layer, differences as high as 10% in the modulus can be made when comparing the possible Poisson's ratio conditions to the "Typically Assumed";
4) Based on the pavement structure analyzed, it appears that the base aggregate layer is the pavement layer that is most influenced by the potential range in Poisson's Ratio values.

The second sensitivity analysis was conducted using the Mechanistic-Empirical Pavement Design Guide Software (MEPDG). The MEPDG software allows for the direct input of the Poisson Ratio value for all unbound material. For the analysis, the same pavement structure used in the FWD simulation was utilized with default traffic data. However, in this analysis, only 8 simulations were conducted; 1) 4 simulations varying the Poissons Ratio of the base aggregate while keeping the HMA and subgrade constant; and 2) 4 simulations varying the Poissons Ratio of the subgrade soil while keeping the HMA and subgrade constant. The generated data from this analysis in now be compiled and will be available for review during the quarterly meeting.

2. Proposed activities for next quarter by task:

A review of all laboratory testing will be quickly conducted. If it is determined that no more laboratory testing is needed, then the development of a final report will immediately begin. Otherwise, a small amount of laboratory testing may be needed prior to the final report.

3. List of deliverables provided in this quarter by task (product date):

N.A.

4. Progress on Implementation and Training Activities:

N.A.

5. Problems/Proposed Solutions:

N.A.

Total Project Budget	$426,111
Modified Contract Amount:	
Total Project Expenditure to date	$365,903
% of Total Project Budget Expended	86%

* These are approximate expended amounts for the project; these estimates are for reference only and should not be used for official accounting purposes. For a more accurate project accounting please review the quarterly invoice for this project.